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Response of Green Bean (*Phaseolus Vulgaris* L.) to Mulching and Cow Manure Application in Sudan Savanna, Nigeria

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Abstract*: Mulching is a common strategy used by farmers worldwide to conserve soil moisture and suppress weed growth in crop production. This experiment was conducted during the rainy season 2020 at the Teaching and Demonstration farm of the Department of Agricultural Education, Federal College of Education, Katsina, located in the Sudan Savanna of Nigeria. The study aimed to assess the response of green beans to different forms of mulches and rates of cowmanure. The treatments comprised three forms of mulches (no mulch, grass mulch and polythene mulch) and three levels of cow manure (0, 5 and 10 t ha^{-1}). The treatments were combined factorially and arranged in a randomized complete block design (RCBD) with three replications. The data collected on canopy height, number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1}, number of pods plant^{-1}, pod weight plant^{-1} and green pod yield of green bean were analyzed using the Genstat Statistical package, and means were separated using Student Newman Keuls at a 5 % probability level. The study showed that polythene mulch significantly recorded higher mean values in most studied characters than grass mulch and control. The results also revealed that the application of cow manure at10 t ha^{-1} significantly increased most of the studied parameters. Based on the results of this study, polythene mulch is recommended in this location. Moreover, cow manure at 10 t ha^{-1}is recommended to increase green bean productivity in this agroecological zone.*

Keywords: *Mulch, cow manure, green bean, growth, yield*

INTRODUCTION

Green beans (*Phaseolus vulgaris* L.), popularly known as string beans, have long edible pods with little inside seeds (Datt *et al.,* 2015). Green beans are a primary dietary protein source for most Sub-Saharan Africans and Latin Americans, accounting for around 20% of total protein intake (Broughton *et al.,* 2003). Theyare utilized for human consumptionand are low in cholesterol and abundant in protein, fibre, phosphorus, iron, and vitamin B1 (Zeyada and Abdalla, 2014). The yield of green beans is low in tropical soil due to nutrient deficits, particularly nitrogen and phosphorus, which are required for crop growth and yield (Singh et al., 2003). Green bean output may also be low due to a lack of information and nutritional requirements of the crop, among other issues (Ibrahim *et al.,* 2021). Legumes are known for fixing atmospheric nitrogen in the soil and improving soil conditions. Green beansare less able to fix atmospheric nitrogen in the soil than

other leguminous crops (Feleafel and Mirdad, 2014). Therefore, it is necessary to supplement its inability byapplyingorganic or inorganic nitrogen sources.Thus,producing green beans under soil application with mulch and cow manureas substitutes for chemical fertilizers can improve green bean growth, yield, and soil fertility.This practice lowered the use of mineral fertilizers while improving soil fertility (Haruna *et al.,* 2018).

Mulches preserve moisture and lessen soil erosion and nutrient leaching on poorly drained soil (Carmichael *et al.,* 2012). Surface-applied mulches reduce soil water evaporation, increasing the chance of greater water conservation, which is critical for encouraging the growth of semi-arid dryland crops (Lamont, 1999). Reduced yield in crop production, particularly in arid and semi-arid locations, results from limited water supplies (Kwambe *et al.,* 2015). Effective soil management practices are essential in tropical regions, where there is a high population density and incorrect and intensive land use, which leads to soil erosion and degradation and poorer crop yields (Tumuhairwe and Gumbs, 1983).

Organic manures are typically used in large quantities, proportional to chemical fertilizers (Adzemi and Haruna, 2017). Organic manures increase soil fertility by promoting microbial biomass (Haruna *et al.,* 2018). It contributes to increasing soil organic carbon contents and improving soil productivity by increasing the activities of the useful microorganisms in the soil (Feleafel and Mirdad, 2014).
This study aims to evaluate the effects of mulching and cow manure application on the growth and yield of green beans.

MATERIALS AND METHODS

Experimental Sites

The experiment was conducted during the rainy season of 2020 at the Teaching and Demonstration Farm of the Department of Agricultural Education, Federal College of Education, Katsina (Latitude 12^{o} 56'N and Longitude 7^{o} 36' E; 464 m above sea level), located at the Sudan Savanna of Nigeria.

Treatments and Experimental Design

The treatments comprised three forms of mulches (no mulch, grass mulch and polythene mulch) and three rates of cowmanure (0, 5 and 10 t ha^{-1}). The treatments were factorially combined and replicated three times in a randomized complete block design (RCBD). Mulch was applied immediately after sowing as per treatment. Cow manure was applied two weeks before sowing to allow it to decompose and mineralized.

Cultural Practices

The experimental site was prepared by clearing, ploughing, harrowing, and levelling the land using a hoe. The experimental area comprised three blocks consisting of nine plots each. Each plot was 4.5 x 2 m (9 m^2), comprising six rows 2 m long. The plots were separated by 0.5 m, and the distance between the blocks was 1 m. The net plot size was 3 x 1.5 m (4.5 m^2), consisting of four inner rows. Two seeds per hill were sown when rain was fully established in July at an intra-row spacing of 25 cm and inter-row spacing of 75 cm. Weeding was done manually using a hoe at regular intervals. Neem oil was sprayed to control pests at 2 ml L^{-1} 3 and 5 weeks after sowing.

Data Collection

Five plants were randomly chosen and tagged from each net plot, from which data was measured six weeks after sowing. Canopy height was measured from five tagged plants in each net plot. The height of the five chosen plants was measured using the graduated meter rule from the base to the top of the canopy. The mean height of the sample plants was recorded. The number of branches per plant was counted from five tagged plants from each net plot, and the mean value was recorded. The number of leaves per plant was counted from five tagged plants, and the mean value was recorded.Leaf area per plant was estimated by measuring the length and width of the sample leaves using the meter rule multiplied by a crop factor (0.67), as reported by Yadav (2015). These were estimated from the five tagged plants in each plot. Three leaves were considered per plant, and the mean area of the leaf was recorded. The leaf area per plant was estimated by multiplying the mean size of the leaf by the total number of leaves on the plant.

The number of pods per plant was measuredat harvest, the number of pods produced by five tagged plants per plot was recorded individually, and the mean value was calculated.Pod weight per plant was recorded by weighing the pods harvested from five tagged plants individually per plot. From the weight taken, the mean value was calculated.Green pod yields from two inner rows of each net plot were harvested, weighed, and expressed in kilograms per hectare (kg ha^{-1}).

$$\text{Green pod yield (kg ha}^{-1}) = \frac{\text{Yield per net plot (kg)} \times 10000\ \text{m}^2}{\text{Net plot area (m}^2)}$$

Data Analysis

The data collected from the field were subjected to analysis of variance (ANOVA) using the Genstat Statistical Package (17th edition).Means showing significant differences were separated using Student Newman Keuls (SNK) at a 5 % probability level.

RESULTS

Physical and Chemical properties of soil of the experimental sites

Table 1 shows the study sites' physical and chemical properties of soil. The analysis results indicated that the textural soil class in the study sites was sandy loam. The soil pH indicated that the soil ofthe study sites was slightly acidic. The soil of the experimental site had 1.10 g kg^{-1} of organic carbon, 0.34 g kg^{-1} of total nitrogen, and 10.17 mg kg^{-1} ofavailable phosphorus. The exchangeable bases, Ca, Mg, K, Na, and CEC, were 2.28, 1.36, 0.19, 0.12, and 4.95 cmol kg^{-1}.

Effect of mulching and cow manure on canopy height (cm)

Mulching showsa significant influence on the canopy height of green beans (Table 2). Polythene and grass mulches were found to be statistically similarin the canopy height of green beans. However, both polythene and grass mulchesare significantly higher than the control.

Cow manure application at different rates significantly influencedthe canopy height of green beans (Table 2).The application of cowmanure at 10 t ha^{-1} was significantly ($p < 0.05$) higher than 5 t ha^{-1} and significantly higher than the control treatment.

Effect of mulching and cow manureon the number of branchesplant^{-1}

Mulching significantly influences the number of branches per plant of green beans (Table 2). Polythene and grass mulches were statistically similar in the number of branches per plant of

green beans but significantly higher than the control treatment. However, grass mulch and control treatment are statistically similar.
The application of cowmanure at different rates significantly influencedthe number of branches per plant (Table 2). Application of 10 and 5 tha^{-1} of cowmanure was statistically similar but significantly higher than the control.

Effect of mulching and cow manureonthe number of leaves $plant^{-1}$
Mulching significantly influences the number of green bean leaves per plant (Table 2). Polythene and grass mulches were statistically similar in the number of leaves per plantof green beans but significantly higher than the control. Moreover, grass mulch and control were statistically similar.
The application of cowmanure at different rates significantly influencedthe number of leaves per plant of green beans (Table 2). Application of 10 and 5 t ha^{-1} of cowmanure was statistically similar but significantly higher than the control treatment.

Effect of mulching and cow manureon the leaf area $plant^{-1}$ (cm^2)
Mulching significantly influencesthe leaf area per plant of green beans (Table 2). Polythene and grass mulches werestatistically similar per green bean plant leaf area but significantly higher than the control. Moreover, grass mulch and control are statistically similar.
Cowmanure application at different rates significantly influenced leaf area per plant of green beans (Table 2). Application10 and 5 t ha^{-1} of cowmanure werefound to be statistically similar concerning leaf area per plant of green bean but significantly higher than the control. Moreover, applying 5 t ha^{-1}cow manureand control produceda statistically similar leaf area per plant.

Effect of mulching and cow manureonthe number of pod $plant^{-1}$
Mulching significantly influencesthe number of pods per plant of green beans (Table 2). Polythene and grass mulches werestatistically similar inthe number of pods per green bean plant but significantly higher than the control. Moreover, grass mulch and control were found to be statistically similar.
Application of cowmanure at different rates showed a significant variation in the number of pods per plant of green beans (Table 2). Application of 10 and 5 t ha^{-1} of cowmanure was statistically similar but significantly higher than the control.

Effect of mulching and cow manureonpod weight$plant^{-1}$ (g)
Mulching significantly influences pod weight per green bean plant (Table 2). Polythene and grass mulches werestatistically similar in pod weight per green bean plant but significantly higher than the control.
The application of cowmanure at different rates showed a significant variation in pod weight per green bean plant (Table 2). Applying 10 and 5 t ha^{-1} of cow manure produced statistically similar pod weight per plant but was significantly higher than the control.
Effect of mulching and cow manureon green pod yield (Kg ha^{-1})
Mulching shows no significant influence on the green pod yield of green beans (Table 2). All the treatments were found to be statistically similar.

Application of cowmanure at different rates showed a significant differenceinthe green pod yield of green beans (Table 2). Applying 5 t ha^{-1} of cow manure and control produced a statistically similar green pod yield but was significantly lower than 10 t ha^{-1} of cowdung.

Table 1: Physical and chemical properties of soil of the experimental siteat FCE Katsina in the 2018 rainy season

Properties	FCE Katsina
Physical (%)	
Sand	78.80
Silt	11.70
Clay	9.50
Textural class	Sandy loam
Chemical composition	
pH in water	6.93
pH ($CaCl_2$)	6.54
Organic carbon (g kg^{-1})	1.10
Total nitrogen (g kg^{-1})	0.34
Available phosphorus (mg kg^{-1})	10.17
Exchangeable bases (cmol kg^{-1})	
Ca++	2.28
Mg++	1.36
K+	0.19
Na+	0.12
CEC ($cmol^{+}$ kg^{-1})	4.95

Table 2: Effect of Mulching and Cow manure on canopy height (cm), number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1} (cm^2), number of pods plant^{-1}, pod weight plant^{-1} (g) and green pod yield (Kg ha^{-1})

Treatment	Canopy height (cm)	No. of branches plant^{-1}	No. of leaves plant^{-1}	Leaf area plant^{-1}(cm^2)	No. of pods plant^{-1}	Pod weight plant^{-1}	Green pod yield (Kg ha^{-1})
Mulch (MC)							
No mulch	17.37b	6.60b	21.93b	1083.56b	16.36b	63.08b	3376.59
Grass mulch	19.63a	7.18ab	23.47ab	1261.95ab	17.27ab	65.96a	3489.99
Polythene mulch	20.06a	7.40a	24.33a	1307.44a	18.24a	67.31a	3347.82
$LSD_{0.05}$	1.597	0.656	1.948	193.390	1.807	2.727	228.280
Cowmanure (CM)							
0 t ha^{-1}	16.16c	6.33b	21.20b	1038.75b	15.24b	60.87b	3195.34b
5 t ha^{-1}	19.43b	7.13a	23.49a	1224.70ab	17.62a	66.73a	3355.26b
10 t ha^{-1}	21.47a	7.71a	25.04a	1389.51a	19.00a	68.73a	3663.80a
$LSD_{0.05}$	1.597	0.656	1.948	193.390	1.807	2.727	228.280
Interaction							
MC x CM	0.419	0.766	0.547	0.863	0.331	0.801	0.238

Means followed by the same letter(s) in a column are not significantly different at $p < 0.05$ using Student Newman Keuls (SNK).

DISCUSSION

The significant increase in the productivity of green beans recorded in this research by using different forms of mulches could be dueto the ability of mulches to conserve moisture and improve the activities of the soil microorganism (Singh and Saggar, 1997). Grass and polythene mulches create a favourable environment at the green bean's root zone, thereby increasing nutrient absorption by the root and increasing its productivity. The findings of this research arein harmony with the report made by Kwambe *et al.* (2015), who reported asignificant increase inthe growth and yield of green beans grown with rice bran mulch.

The significant variation recorded in most of the studied characters of green beans regarding cowmanure application may be associated with the ability of cowmanure to supply adequate nutrients for plant growth (Adzemi and Haruna, 2017). Using 10 t ha^{-1} of cowmanure in this study significantly increases the performance of green beans. The reasonis that cowmanure is known to have a good composition of essential nutrients required by plants, such as N, P, and K, which are gradually released into the soil (Haruna *et al.,* 2018). These nutrients enhance the productivity of the green beans in terms of both growth and green pod yield. This study aligns with the findings of Datt (2015), who reported that applying organic fertilizer is an important practice for maintaining soil fertility and is environmentally friendly. This is because the nutrients in organic manure are released more gradually and kept in the soil for a longer period, ensuring a lasting benefit.

Conclusion

The study results showed that polyethene and grass mulches improved the growth and yield of green beans by conserving moisture and suppressing weed growth. It is recommended to use polyethene mulch for green bean production in the Sudan Savanna of Nigeria. Where there is a limited supply of polyethene mulch, grass mulch can be used. The study also shows that the growth and green pod production of green beans were enhanced by applying cow manure.

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